

## **Title: Sketching DNA**

### **Brief Overview:**

This unit will construct a DNA pattern using Geometer's Sketchpad. The construction will involve translation, rotations, and reflections. Students will use patterns to represent and identify traits.

### **NCTM 2000 Principles for School Mathematics:**

- **Equity:** *Excellence in mathematics education requires equity - high expectations and strong support for all students.*
- **Curriculum:** *A curriculum is more than a collection of activities: it must be coherent, focused on important mathematics, and well articulated across the grades.*
- **Teaching:** *Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.*
- **Learning:** *Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.*
- **Assessment:** *Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.*
- **Technology:** *Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.*

### **Links to NCTM 2000 Standards:**

- **Content Standards**

#### **Geometry**

Students will make constructions using translation, reflections, and rotations; use various representations to help understand the effects of simple transformations; visualize three-dimensional objects from different perspectives and analyze their cross sections; and use geometric models to gain insights into, and answer questions in areas of science.

#### **Data Analysis and Probability**

Students will understand the concepts of conditional probability and independent events. They will understand how to compute the probability of compound events.

- **Process Standards**

**Mathematics as Problem Solving, Reasoning and Proof, Communication, Connections, and Representation**

These five process standards are threads that integrate throughout the unit, although they may not be specifically addressed in the unit. They emphasize the need to help students develop the processes that are the major means for doing mathematics, thinking about mathematics, understanding mathematics, and communicating mathematics.

With the use of the Geometer's Sketchpad, the students will use problem-solving techniques to construct a DNA model. The students will also use reasoning and proof skills to draw conclusions from the models. Their conclusions will be communicated through verbal exchange to identify various DNA models. Conclusions will be used to make connections and representation of new DNA models.

**Links to Maryland High School Mathematics Core Learning Units:**

**Geometry, Measurement, and Reasoning**

- **2.1.1**

Students will construct geometric figures using technology.

- **2.1.3**

Students will use transformations to move figures and create designs.

**Data Analysis and Probability**

- **3.2.1**

Students will make informed decisions and predictions based upon the results of simulations and data from research.

**Links to National Science Education Standards:**

- **1.12.4**

Students will formulate a model (physical, conceptual, or mathematical) using an appropriate instrument.

- **1.12.6**

Students will interpret and communicate findings through speaking, writing, and drawing using developmentally appropriate methods.

- **1.12.10**

Students will design, construct, and use a computer model to make predictions about actual events.

**Links to Maryland High School Science Core Learning Units:**

- **1.5.1**

Students will demonstrate the ability to summarize data, investigate results and processes through drawing, writing, and/or oral communication.

- **1.5.3**

Students will create and interpret a scale drawing.

**Grade/Level:**

Grades 9-12; Geometry/Biology

**Duration/Length:**

Two to three class periods

**Prerequisite Knowledge:**

Students should have working knowledge of the following skills:

- Basic skills and usage of the Geometer's Sketchpad
- Translation skill on the Geometer's Sketchpad
- Construction of a perpendicular line
- Combinations and probability of independent events
- Basic knowledge of human genes that compose the human chromosomes

**Student Outcomes:**

Students will:

- construct a DNA model using Geometer's Sketchpad.
- interpret and compare individual models of DNA.
- find the probability of an independent event.

**Materials/Resources/Printed Materials:**

- Geometer's Sketchpad
- Student Activity Sheets #1 and #2
- Student Assessment

**Development/Procedures:**

- Teacher will review any necessary computer procedures.
- Student will complete Student Activity Sheet #1. (Advanced or Beginner)
- Student will complete Student Activity Sheet #2.
- An assessment is provided to conclude the activity.

**Assessment:**

An assessment activity, answer sheet, and scoring rubric are provided.

**Extension/Follow Up:**

- Additional animation activities using Geometer's Sketchpad
- Additional probability activities using Geometric probability
- Additional constructions of various mixtures of traits

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## **Assessment**

### **Teacher Guide**

#### **Introduction**

The assessment should be given at the end of this unit and will determine whether students learned the concept taught.

#### **Objectives Covered**

Students will:

- construct a DNA model using Geometer's Sketchpad.
- interpret and compare individual models of DNA.
- find the probability of an independent event.

#### **Tools/Materials needed for Assessment**

- Geometer's Sketchpad
- Sketching DNA Assessment sheet
- Pencil

#### **Administering the Assessment**

There are two parts to the assessment, first the construction of a DNA model using Student Activity Sheet #1, and secondly, the Sketching DNA Assessment Sheet. The rubric for the DNA model is included and the answer key for the assessment sheet as well.

NAME\_\_\_\_\_

DATE\_\_\_\_\_

### **Student Activity #1-Advanced**

Directions: Follow the steps below to draw a DNA model using the Geometer's Sketchpad on your computer. Use the DNA map to designate your characteristic traits. Print your DNA strand. If you don't have a color printer, use markers or colored pencils to color your copy.

#### **Part 1-Steps to make a 3D animated DNA strand:**

- 1) Draw a circle to the left of the screen and a vertical diameter. Hide the endpoints of the diameter and the free point on the circle.
- 2) Create a small vertical segment and place it next to the circle.
- 3) Draw a vertical line segment at least ten times the length of the one in #2 to the right of the screen (not part of or connected to the circle) and label it the DNA axis of rotation.
- 4) Create a vector on the segment from #2 by selecting the bottom point then the next point up, while holding the shift key by using the transform menu. Select the bottom point on the DNA axis of rotation. Then transform- translate-by marks along the DNA axis of rotation. You should see a new point on the DNA axis of rotation that is congruent to the segment in #2. Continue this process using the last point created until you have 10 equidistant points on DNA axis of rotation.
- 5) Draw a point on the circle. Select the center of the circle and mark it as center. Then, while holding the shift key, select the point you created on the circle.
- 6) Rotate the point on the circle about the center at 36 degrees by using the transform-rotate menu. Continue this until you have 10 equidistant points on the circle.
- 7) Start at your first point and draw a line through the point and perpendicular to the diameter.
- 8) Construct the point of intersection between the diameter and the perpendicular line. Hide the perpendicular line and create the segment between the point on the circle and the intersection point.
- 9) Mark the vector from the intersection point to the point on the circle.
- 10) Choose the first equidistant point at the bottom of the vertical line segment from step #2 and translate the vector. Remember this point since you'll use it to animate.
- 11) Repeat steps 7 through 10 for the 9 equidistant points on the circle counter-clockwise around the circle. Be sure to go in order up the line segment also.
- 12) Construct segments between the consecutive translated points around the DNA axis of rotation.
- 13) Select the DNA axis of rotation and mark it as your mirror. Select all the translated points around the DNA axis of rotation by holding down the shift key. Reflect the points about the DNA axis of rotation.

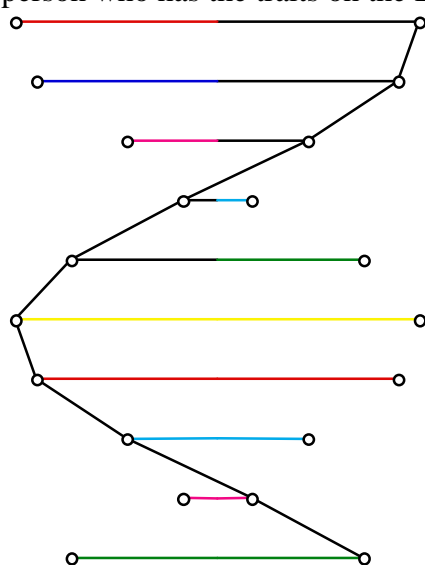
- 14) Construct horizontal line segments between each point in #11 and their reflection in #13.
- 15) Choose your colors for each of the ten horizontal segments or “steps” of the DNA strand that you created to describe yourself using the DNA trait map instructions on the next page.
- 16) Select the point on the circle that you chose in step #10. Then select the circle while holding down the shift key. Animate the point around the circle.
- 17) Hide everything except the helix and the animate button.
- 18) Double click on the animate button and watch the “DNA helix” turn giving it a 3-D look.
- 19) Stop the animate and print a copy of your DNA strand. If you don’t have a color printer, you will have to color your copy with markers or colored pencils.
- 20) Write a “code name” for yourself on the back of your paper and turn it into your teacher.
- 21) Show all hidden objects and print the DNA helix again with all hidden shown. Turn this paper into your teacher with your name on the back.

### DNA Trait Map Instructions:

<u>Ladder Step</u>	<u>Characteristic</u>	<u>Description</u>	<u>Computer Color Choices</u>
Top rung	Eye Color	Brown Green Blue Gray Hazel Black	Red Green Blue Yellow Fuchsia Black
Second rung	Hair Color	Brown Red Blond Black	Purple Red Yellow Black
Third rung	Gender	Male Female	Blue Fuchsia
Forth rung	Hair	Curly Straight	Blue Yellow
Fifth rung	Eyebrows	Bushy Thin	Green Red
Sixth rung	Teeth	Space No space	Black Yellow
Seventh rung	Height	Tall Average Short	Red Blue Yellow
Eighth rung	Ear Lobes	Attached Not attached	Fuchsia Blue
Ninth rung	Tongue curling	Curl No curl	Fuchsia Blue
Tenth rung	Foot size	Long Average Short	Green Blue Yellow



**Part 2**-Use the DNA map below and the DNA trait map instructions above to write a description of the person who has the traits on the DNA strand below.



RED  
PURPLE  
FUCHSIA  
BLUE  
GREEN  
YELLOW  
RED  
BLUE  
FUCHSIA  
GREEN

Description:

**Part 3**-Choose a DNA strand from someone in your class other than your own. Write a description of that person and choose who you think they are based on your description. Check with the person to see if you were correct. Keep with it until you find the person and hand them back their DNA strand. Justify each choice until you find the correct student.

Description:

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Student Guess

Circle One

Guess' Initials

First guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Second guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Third guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Turn this activity sheet with **your** DNA strand into your teacher. Be sure to write your name on all sheets.

NAME\_\_\_\_\_

DATE\_\_\_\_\_

**Student Activity #1-Beginner**

Directions: Follow the steps below to draw a DNA model using the Geometer's Sketchpad on your computer. Use the DNA map to designate your characteristic traits. Print your DNA strand. If you don't have a color printer, use markers or colored pencils to color your copy.

**Part 1-Steps to make a 2D DNA strand:**

- 1) Draw a short line segment AB on a diagonal near the top of the screen.
- 2) Select the first point A.
- 3) Transform-Mark Center A.
- 4) Select segment AB then Point B.
- 5) Transform-Rotate (-60).
- 6) Transform-Mark Center B' (this new point is B').
- 7) Select second segment then Point A. (holding down the shift key)
- 8) Transform-Rotate (60).
- 9) Place two more points on each of the 3 line segments.
- 10) Select segment AB' and construct its midpoint.
- 11) Draw a horizontal line through the midpoint of segment AB'.
- 12) Select the horizontal line.
- 13) Transform-Mark mirror.
- 14) Edit- Select All.
- 15) Transform-Reflect.
- 16) Hide the vertical line.
- 17) Construct horizontal segments between all points and their reflected images.
- 18) Choose your colors for each of the "steps" of the DNA strand to describe yourself using the DNA map below. Print a copy of your DNA strand. If you don't have a color printer, color the helix by hand after you've printed it.
- 19) Show all hidden objects and print the DNA strand with all hidden.

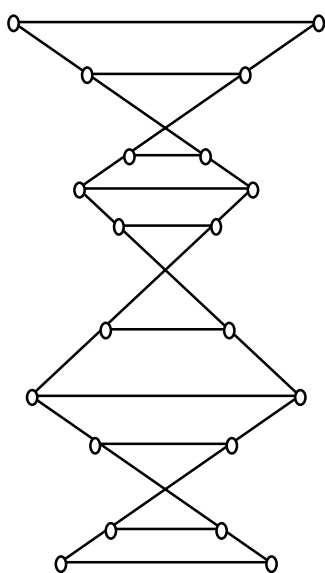
**DNA Trait Map Instructions:**

<u>Ladder Step</u>	<u>Characteristic</u>	<u>Description</u>	<u>Computer Color Choices</u>
Top rung	Eye Color	Brown	Red
		Green	Green
		Blue	Blue
		Gray	Yellow
		Hazel	Fuchsia
		Black	Black
Second rung	Hair Color	Brown	Purple
		Red	Red
		Blond	Yellow
		Black	Black
Third rung	Gender	Male	Blue
		Female	Fuchsia
Forth rung	Hair	Curly	Blue
		Straight	Yellow
Fifth rung	Eyebrows	Bushy	Green
		Thin	Red
Sixth rung	Teeth	Space	Black
		No space	Yellow

Seventh rung	Height	Tall	Red
		Average	Blue
		Short	Yellow
Eighth rung	Ear Lobes	Attached	Fuchsia
		Not attached	Blue
Ninth rung	Tongue curling	Curl	Fuchsia
		No curl	Blue
Tenth rung	Foot size	Long	Green
		Average	Blue
		Short	Yellow

When you complete your personal DNA map, print it or color the printed copy. Put a code name on the back of your copy and pass it into your teacher.

**Part 2**-Use the DNA map below and the DNA trait map instructions above to write a description of the person who has the traits on the DNA strand below.



RED  
PURPLE  
FUCHSIA  
BLUE  
GREEN  
YELLOW  
RED  
BLUE  
FUCHSIA  
GREEN

Description:

**Part 3**-Choose a DNA strand from someone in your class other than your own. Write a description of that person and choose who you think they are based on your description. Check with the person to see if you were correct. Keep with it until you find the person and hand them back their DNA strand. Justify each choice until you find the correct student.

Description:

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Student Guess

Circle One

Guess' Initials

First guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Second guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Third guess \_\_\_\_\_

Correct/Incorrect

Initials\_\_\_\_\_

Turn this activity sheet with **your** DNA strand into your teacher. Be sure to write your name on all sheets.

## Student Activity #2

### Probability Review

#### Combinations

You are in charge of production of making Cabbage Patch dolls and the only thing you change to individualize the dolls are their hair color and eye color.

##### 6 eye colors

brown  
green  
blue  
gray  
hazel  
black

##### 4 hair colors

brown  
red  
blond  
black

How many different dolls can be made?

$$6 \times 4 = \underline{24}$$

- 1) Suppose we add male and female dolls, what is the new combination?
- 2) Suppose we add to #1 the height (3 sizes), what is the new combination?

#### Probability

Using the eye and hair combination above what is the probability of getting blond hair and blue eyes dolls out of the 24 dolls.

$$1/6 \times 1/4 = 1/24$$

$$\frac{\text{number of favorable outcomes}}{\text{number of total outcomes}}$$

- 1) If the events are equal, what is the probability of male doll having red hair and hazel eyes?
- 2) Using all 10 traits from activity #1, what is the probability that one will fit your ten traits?
- 3) Using the same 10 traits, what is the probability that a person at random would be short, with attached ear lobes and a long foot size?
- 4) Using the same 10 traits, what is the probability that a person at random would have bushy eyebrows, a curled tongue, and no space between teeth?

## Student Activity #2 Answer Key

### Probability Review

#### Combinations

You are in charge of production of making Cabbage Patch dolls and the only thing you change to individualize the dolls are their hair color and eye color.

##### 6 eye colors

brown  
green  
blue  
gray  
hazel  
black

##### 4 hair colors

brown  
red  
blond  
black

How many different dolls can be made?

$$6 \times 4 = \underline{24}$$

- 1) Suppose we add male and female dolls, what is the new combination? *48*
- 2) Suppose we add to #1 the height (3 sizes), what is the new combination? *144*

#### Probability

Using the eye and hair combination above what is the probability of getting blond hair and blue eyes dolls out of the 24 dolls.

$$1/6 \times 1/4 = 1/24$$

$$\frac{\text{number of favorable outcomes}}{\text{number of total outcomes}}$$

- 1) If the events are equal, what is the probability of male doll having red hair and hazel eyes? *1/48*
- 2) Using all 10 traits from activity #1, what is the probability that one will fit your ten traits? *1/13824*
- 3) Using the same 10 traits, what is the probability that a person at random would be short, with attached ear lobes and a long foot size? *9/13824*
- 4) Using the same 10 traits, what is the probability that a person at random would have bushy eyebrows, a curled tongue, and no space between teeth? *8/13824*

## Sketching DNA Assessment

NAME \_\_\_\_\_

Using the instructions below, answer questions 1 - 6.

### DNA Trait Map Instructions:

<u>Ladder Step</u>	<u>Characteristic</u>	<u>Description</u>	<u>Computer Color Choices</u>
Top rung	Eye Color	Brown Green Blue Gray Hazel Black	Red Green Blue Yellow Fuchsia Black
Second rung	Hair Color	Brown Red Blond Black	Purple Red Yellow Black
Third rung	Gender	Male Female	Blue Fuchsia
Forth rung	Hair	Curly Straight	Blue Yellow
Fifth rung	Ear Lobes	Attached Not attached	Fuchsia Blue

- 1) If you take away the fifth rung in your DNA, how many **fewer** combinations do you have? \_\_\_\_\_
- 2) What is the probability of getting a male with brown, curly hair, blue eyes and attached ear lobes from all of the different combinations above? \_\_\_\_\_
- 3) In a class of 24 people, what is the probability of matching a DNA strand that each person in the class made to the correct person with only the top five rungs above? \_\_\_\_\_
- 4) How many combinations of different individuals can you make with the traits above? \_\_\_\_\_
- 5) If you added a sixth rung to your ladder with three characteristics, how many more combinations would you have? \_\_\_\_\_

6) You have a DNA strand with the following characteristics:

Top rung-Red, Second rung-Purple, Third rung-Fuchsia, Forth rung-Yellow, Fifth rung-Blue

\*Describe the person who has these traits using the instructions above.

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\*What is the probability that you could identify this person in a group of 100 people without the DNA instructions from Number 6 above?\_\_\_\_\_

\*If you needed to find the person quickly using the DNA instructions only one rung at a time, state the order of the rungs you would choose and justify your choice.\_\_\_\_\_

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\*What would you do to the DNA strand to get a better chance of guessing the correct person?

How is this used in the real world?\_\_\_\_\_

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## Assessment Key

- 1) 96(1 point)
- 2) 1/192(1 point)
- 3) 1/24(1 point)
- 4) 192(1 point)
- 5) 384(1 point)
- 6) \*Key words: Brown eyes; straight, brown hair; female; not attached ear lobes

\*1/100

\*Gender first, then hair, ear lobes, hair color, eye color. Choose the characteristics with the least number of descriptors to the ones with the most. Choose the characteristics that are most noticeable at first glance to those least noticeable.

\*Change the order as noted above. Add more characteristics or more descriptors per characteristic. Used in the real world to find criminals, heredity, identity. (ECR-4 points: Use MSDE 4 point rubric.)

### **Rubric for DNA Model**

- 4-Complete DNA model and all hidden parts.
- 3-Most of DNA model completed and most hidden parts.
- 2-Some of DNA model completed and some hidden parts.
- 1-DNA model incomplete and no hidden parts.

